Merit Partnership Pollution Prevention Project for Metal Finishers

REDUCING RINSE WATER USE WITH CONDUCTIVITY CONTROL SYSTEMS

The Merit Partnership is a joint venture between U.S. Environmental Protection Agency (EPA) Region 9, state and local regulatory agencies, private sector industries, and community representatives. The partnership was created to promote pollution prevention (P2), identify P2 technology needs, and accelerate P2 technology transfer within various industries in southern California. One of these industries is metal finishing, which is represented in the Merit Partnership by the Metal Finishing Association of Southern California (MFASC). Together, MFASC, EPA Region 9, and the California Manufacturing Technology Center (CMTC) established the Merit Partnership P2 Project for Metal Finishers. This project involves implementing P2 techniques and technologies at metal finishing facilities in southern California and documenting and sharing results. Technical support for this project is provided by Tetra Tech EM Inc. (formerly PRC Environmental Management, Inc.). The project is funded by the Environmental Technology Initiative and EPA Region 9, and is implemented, in part, through CMTC by the National Institute of Standards and Technology.

INTRODUCTION

Rinse operations significantly impact product finish and plating operations by removing concentrated process solutions from part surfaces and minimizing dragin to subsequent operations. At most metal finishing facilities, water continuously flows through rinse tanks to provide proper rinsing. However, many facilities use more rinse water than necessary, which results in high water bills and wastewater treatment costs. During metal finishing, as parts are removed from a process bath and dipped into a rinse tank, the concentrations of chemicals in the rinse water increase, thereby increasing rinse water conductivity. Conductivity control systems monitor the conductivity of the rinse water to maintain chemical concentrations at levels that provide adequate rinsing and prevent excessive dragin to subsequent process tanks. Conductivity control systems reduce water use by adding water to rinse tanks only when necessary instead of continuously at a constant rate.

Benefits of Reducing Rinse Water Use

The advantages of reducing rinse water flow include:

- Decreased water use
- Decreased wastewater generation
- Decreased wastewater treatment chemical use
- Decreased sludge generation

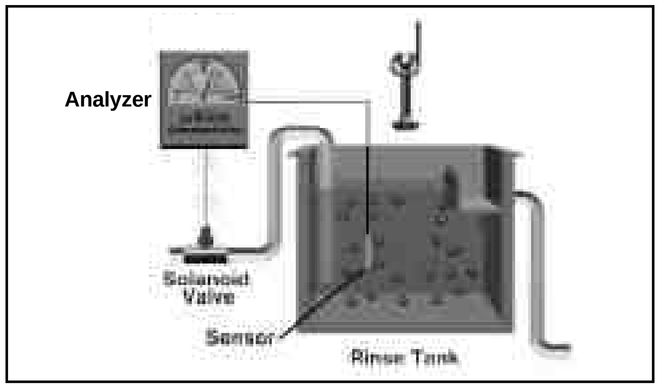

Figure 1. Conductivity Control System Components

CONDUCTIVITY CONTROL SYSTEMS

A conductivity control system consists of three main components: (1) a conductivity sensor, (2) a conductivity analyzer, and (3) a solenoid valve (see Figure 1). The conductivity sensor is a probe placed in the rinse tank to measure rinse water conductivity. The conductivity analyzer is the signal processing unit that controls the system. The conductivity analyzer receives input from the sensor and determines rinse water conductivity. The conductivity analyzer features a programmable or adjustable set point and deadband. When the rinse water conductivity reaches the set point, the analyzer opens the solenoid valve to release water into the rinse tank, thereby reducing the conductivity of the rinse water. The deadband is the conductivity range within which the solenoid valve will remain open after being activated by the analyzer. When rinse water conductivity decreases to a level below the deadband, the analyzer closes the solenoid valve to stop water flow to the rinse tank (see Figure 2).

California Manufacturing Technology Center

United States Environmental Protection Agency

Tetra Tech EM Inc.

MFASC

DECEMBER 1996

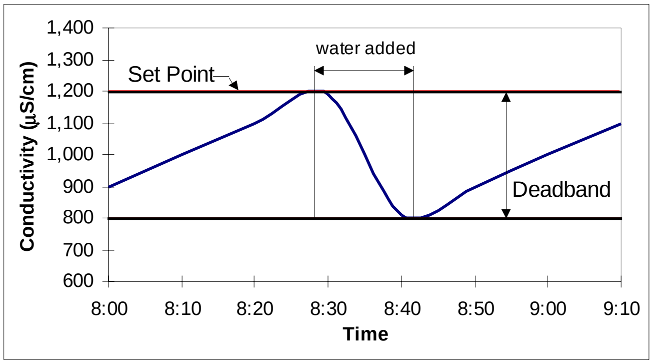

Figure 2. Set Point and Deadband are Key Parameters for Conductivity Control System Operation

CONVENTIONAL AND ELECTRODELESS CONDUCTIVITY SENSORS

Two types of conductivity sensors are available: (1) conventional and (2) electrodeless. Conventional conductivity sensors, also known as contacting sensors, consist of two electrodes that contact the water with a low-level electrical potential between them (see Figure 3). The water's ability to conduct the electricity is proportional to its conductivity. The electrodes are sized and spaced to provide a known cell constant, which corresponds to a specific operating range that must match the conductivity range of the rinse water. The electrodes in a conventional sensor may attract ions and other charged particles and eventually become encrusted or "fouled," causing the sensor to provide inaccurate conductivity measurements. To ensure accurate conductivity measurements, sensors must be cleaned as frequently as every two weeks and calibration checks should be performed monthly.

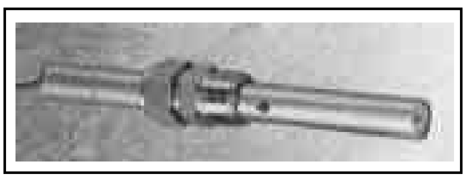

Figure 3. Conventional Sensor

Electrodeless sensors eliminate the fouling problems associated with conventional sensors. The electrodeless sensor consists of two torroids, or wire loops, sealed within a nonconductive polyether ether ketone (PEEK), polypropylene, or polyvinylidene fluoride (PVDF) casing (see Figure 4). The first torroid induces an electrical current in the water without contacting the water. The second torroid in the sensor senses the magnitude of the induced current, which is proportional to the conductivity of the solution. Because electrodeless sensors do not involve an applied electrical potential, fouling does not occur. Consequently, electrodeless sensors are easier to operate and maintain because they require less frequent cleaning. Electrodeless sensors are also more versatile than conventional sensors because they are capable of measuring a large conductivity range, not just a limited conductivity range. Monthly calibration checks of electrodeless sensors should be conducted to ensure accurate conductivity measurement.

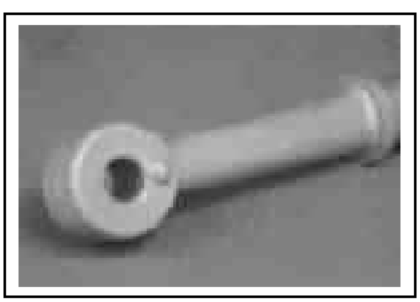

Figure 4. Electrodeless Sensor

Keys to Success:
Sensor Installation and Rinse Water Circulation

Proper sensor placement and good rinse water circulation are required to ensure accurate conductivity readings and maximize rinsing efficiency. Conductivity sensors should be installed in the rinse tank at the following locations:

- ☑ Halfway down from the rinse water level
- ☑ Away from any stagnant areas
- ☑ Away from the clean water inlet
- ☑ Several inches away from the tank wall
- ☑ In the final rinse tank of a multistage counterflow rinse

Good rinse water circulation should be maintained in the rinse tank by one or more of the following methods:

- ☑ Air agitation
- ☑ Mechanical mixing
- ☑ Double dipping parts
- ☑ Using a diverter or diffuser attachment on the water inlet

SET POINT DETERMINATION

One of the most important steps in implementing a conductivity control system is defining the set point. The set point determines the amount of rinse water used and the upper limit of acceptable chemical concentrations in the rinse water. The higher the set point, the lower the overall rinse water use. To determine the set point, conductivity in the rinse tank should

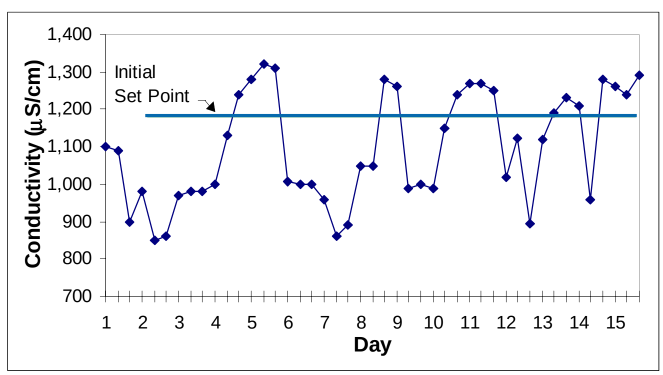

Figure 5. Rinse Water Conductivity Measurements Taken Before Installing a Conductivity Control System to Determine the Initial Set Point

be monitored before system installation to determine its conductivity range (see Figure 5). Initially, conductivity control system set points should be established at the high end of the rinse water conductivity range. Set points can be increased if process operations remain unaffected and further reductions in rinse water use are desired. Set points can be reduced if parts are not adequately rinsed or if dragin to subsequent process tanks adversely affects process operations. A record of set points, process bath conditions, and parts rejected because of poor rinse quality should be maintained to help determine optimal set points.

Things to Consider When Selecting Components

Considerations that affect the type of conductivity control system components selected include the following:

- ***Conductivity range of the rinse water:*** Analyzers and conventional conductivity sensors are designed to measure certain conductivity ranges.
- ***Analyzer mounting configuration:*** Analyzers are equipped with special hardware for mounting on an instrument panel, flat surface, or pipe.
- ***Analyzer mounting location:*** Analyzers are available with NEMA 4X water- and corrosion-resistant enclosures for installation near process tanks.
- ***Number of channels on the analyzer:*** Some analyzers are capable of accepting inputs from two sensors so that water flow in two rinse tanks can be controlled.
- ***Chemical concentrations in the rinse tank:*** The chemical concentrations in the rinse tank, which are determined by the type and volume of dragin from preceding processes, can affect the type of sensor selected. Electrodeless sensors may be more appropriate in rinse tanks with high chemical concentrations because they do not foul.

CASE STUDY: ARTISTIC PLATING AND METAL FINISHING, INC.

The Merit Partnership sponsored a P2 project that involved installing and evaluating conductivity control systems at Artistic Plating and Metal Finishing, Inc. (Artistic), a medium-sized metal finishing facility in Anaheim, California. The main objective of the Artistic P2 project was to evaluate the effectiveness and benefits of using conductivity control systems on various metal finishing processes. The Artistic facility performs copper, nickel, and chrome electroplating on a hand-operated rack line and copper electroplating on a manually-operated barrel hoist line. The facility specializes in electroplating zinc die-cast parts for commercial customers, and operates up to three shifts per day. Wastewater is sent to an on-site wastewater treatment system (WWTS). Treated wastewater is discharged to the local publicly owned treatment works and sludge (filter cake) is disposed of off site.

Conductivity Controlled Rinse Tanks at Artistic

- Acid activation (three)
- Copper cyanide (two)
- Nickel (three)
- Chromium (one)

Nine conductivity control systems were installed at the Artistic facility. Three conductivity control systems were purchased from the Foxboro Company (Foxboro), three from Great Lakes Instruments (GLI), and three from Cole-Parmer Instrument Company (Cole-Parmer). The Foxboro and GLI conductivity control systems use electrodeless sensors and the Cole-Parmer conductivity control systems use conventional sensors. The Foxboro and GLI systems have analyzers with digital displays that allow accurate programming of set points and deadbands and easy system calibration and operation. The Cole-Parmer systems do not have displays, and analog set points and deadbands are adjusted by turning screws in the sensors. Unlike the Cole-Parmer systems, the Foxboro and GLI systems do not include solenoid valves; therefore, valves for these systems were purchased separately from a hardware supplier.

CASE STUDY SYSTEM SETUP

The analyzers for the conductivity control systems on the rack line at the Artistic facility were mounted on a common control panel (see Figure 6). Cables from the analyzers to the sensors and solenoid valves were run below the floor grating and protected from moisture by conduit. The analyzers for the conductivity control systems on the barrel line were mounted on a nearby wall. Artistic monitored rinse water conductivity for 3 weeks before system installation to determine the operating conductivity range of each rinse tank. Based on this information, the initial set point on all analyzers were set at 1,200 microSiemens per centimeter (μS/cm), with a deadband of 50 μS/cm. During 3 months of operation, no negative production impacts occurred (inadequate rinsing or dragin to subsequent process tanks). Artistic may therefore eventually raise the set points.

Figure 6. Analyzer Panel at the Artistic Facility

Conductivity control system maintenance includes monthly calibration checks performed by comparing the conductivities measured by the conductivity control systems with those measured by a calibrated, hand-held conductivity meter. During 3 months of operation, the sensors did not need cleaning. One of the Cole-Parmer conductivity control systems malfunctioned because of a manufacturer's defect. This system was returned to the distributor for replacement.

CASE STUDY COSTS

The costs for conductivity control systems ranged from $290 to $1,140 per system. Other hardware, such as mounting equipment, conduit, and wiring, cost an additional $100 to $250 per system. Installation was performed by an outside contractor for $400 to $600 per system. System operation and maintenance activities are currently performed by a contractor but may eventually be performed by Artistic staff.

Typical Conductivity Control System Costs

	Conventional[a]	Electrodeless[b]
Capital	$290	$1,140
Additional Hardware	$100	$ 250
Installation	$400	$ 600
Total (per system)	$790	$1,990

a Conventional sensor, analyzer with no display, and analog set point and deadband
b Electrodeless sensor, analyzer with digital display, and programmable set point and deadband

Although the conventional conductivity control systems require less capital cost, Artistic believes the electrodeless systems are likely to be more cost-effective in the long term because they are easier to operate and maintain.

CASE STUDY RESULTS

The conductivity control systems were installed at the Artistic facility in August 1996 and after 2 weeks of adjustment have performed effectively. Analyzers with digital displays and programmable set points were easiest to use and allowed better control of rinse water flow than analyzers with no display and analog set points. During 3 months of conductivity control system operation, no adverse impacts on process quality were observed. The conductivity control systems have resulted in the following benefits: (1) decreased rinse water use, (2) decreased wastewater generation, (3) decreased WWTS treatment chemical use, and (4) decreased WWTS sludge generation.

Decreased Rinse Water Use and Wastewater Generation: After 3 months of operation, the conductivity control systems have reduced rinse water use and resulting wastewater generation at Artistic by 43 percent (see Figure 7). According to the facility production manager, production was steady during this period. Artistic has saved a total of $390 per month on city water purchase and sewer discharge fees.

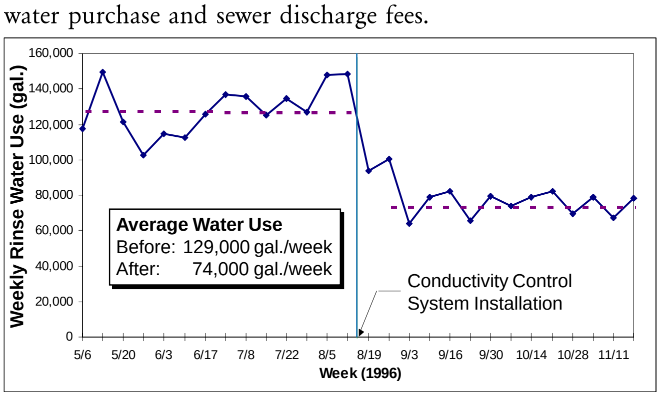

Figure 7. Rinse Water Use at Artistic Decreased 43%

Decreased Wastewater Treatment Chemical Use and Sludge Generation: Conductivity control systems significantly reduce overall rinse water use and wastewater volume; therefore, if dragout remains constant, the average concentration of metals in the wastewater will increase. Studies have shown that treating smaller volumes of more concentrated wastewater can reduce treatment chemical use and associated costs. This effect is realized because electroplaters use treatment chemicals in quantities that greatly exceed stoichiometric requirements. Reducing wastewater volume and treatment chemical use may also reduce the volume of sludge (filter cake) generated because a significant portion of sludge mass can be attributed to treatment chemicals (for example, lime) and their reactions with naturally occurring ions (for example, carbonates, phosphates, and sulfates) present in water that are removed during treatment.

In addition, reduced wastewater generation will result in a lower flow rate through the WWTS, which can increase retention time in the treatment tanks and improve WWTS performance and efficiency, further reducing treatment chemical requirements. Because the evaluation period was not long enough to allow adequate sludge generation data to be gathered and because the facility changed the type of flocculant used in the WWTS, sludge reduction was not quantified.

Conductivity Control System Results

	Per Month		Monthly
	Before	After	Savings
Rinse Water Use	516,000 gal.	296,000 gal.	$280
Wastewater Discharge	516,000 gal.	296,000 gal.	$110
WWTS Chemical Use	$4,000	$3,200	$800
WWTS Sludge		Not Quantified	

Total Cost for Nine Systems = $14,500
Total Savings = $14,300/year
Payback Period = 1.0 year

For more information on the Merit Partnership, this case study, or conductivity control systems, contact the following individuals:

Laura Bloch (EPA Region 9)	at	(415) 744-2279
John Siemak (CMTC)	at	(310) 263-3097
Dan Cunningham (MFASC)	at	(818) 986-8393
Kipton Kahler (Artistic)	at	(714) 632-1496
Kevin Quackenbush (Foxboro)	at	(508) 378-5177
Joseph Novak (GLI)	at	(414) 355-3601
(Cole-Parmer)	at	(800) 323-4340

Assistance for this fact sheet was provided by Tetra Tech EM Inc.